Radiative Forcing of the Stratosphere by SO_2, Ash, and H_2SO_4 Aerosols, During the First 3 Months After the El Chichon Eruption

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Although the radiative effects of volcanic SO_2 and silicate ash are short-lived, the local, instantaneous radiative forcing can be an order of magnitude stronger than that of H_2SO_4 aerosols. To determine the impact for the El Chichon eruption, we used a radiative transfer model to calculate diabatic heating by the El Chichon cloud at three early timesteps, STEP1 = 1 week, STEP2 = 3 weeks, and STEP3 = 3 months after the eruption (April 4, 1982). The radiative heating simulations were run with no H_2SO_4 in STEP1 and no ash in STEP3. The ash was assumed to decay from an optical depth of 0.6 to 0.08, and its modal radius to decrease from about 3 to 1 µm between STEP1 and STEP2. H_2SO_4 aerosols, with a modal radius of 0.4 µm, were assumed to increase from an optical depth of 0.22 to 0.25 between STEP2 and STEP3. SO_2 gas column amounts were taken to be 40, 20, and 6 m atm cm at STEP1, STEP2, and STEP3, respective] y,

The results show extremely large radiative forcing by the ash in STEP1, of up to 20°C/day in the stratosphere. Typical background net heating and cooling rates in the stratosphere are less than 0.5°C/day. The forcing by SO_2 in STEP1 and STEP2 is comparable to that of the H_2SO_4 in STEP2 and STEP3, with a maximum heating of 1 to 2°C/day. By STEP3, the effect of the SO_2 is much less than that of the H_2SO_4 aerosols. The magnitude of the heating and cooling rates are sensitive to the altitude and vertical extent of the volcanic plume. The strong radiative effects of SO_2 and ash in the first couple of months after a large eruption should be included in GCM, radiative-convective, and photochemical models.